Foundations of Modern Networking

SDN, NFV, QoE, IoT, and Cloud

By: William Stallings

Chapter 2

Requirements and Technology

Categories of explicit congestion signaling approaches:

Binary

- A bit is set in a data packet as it is forwarded by the congested node; when a source receives a binary indication of congestion on a logical connection, it may reduce its traffic flow

Credit based

- These schemes are based on providing an explicit credit to a source over a logical connection; the credit indicates how many octets or how many packets the source may transmit
- Common for end-to-end flow control, in which a destination system uses credit to prevent the source from overflowing the destination buffers
- Defined in Frame Relay and Asynchronous Transfer Mode networks

Rate based

- These schemes are based on providing an explicit data rate limit to the source over a logical connection
- The source may transmit data at a rate up to the set limit
- To control congestion, any node along the path of the connection can reduce the data rate limit in a control message to the source

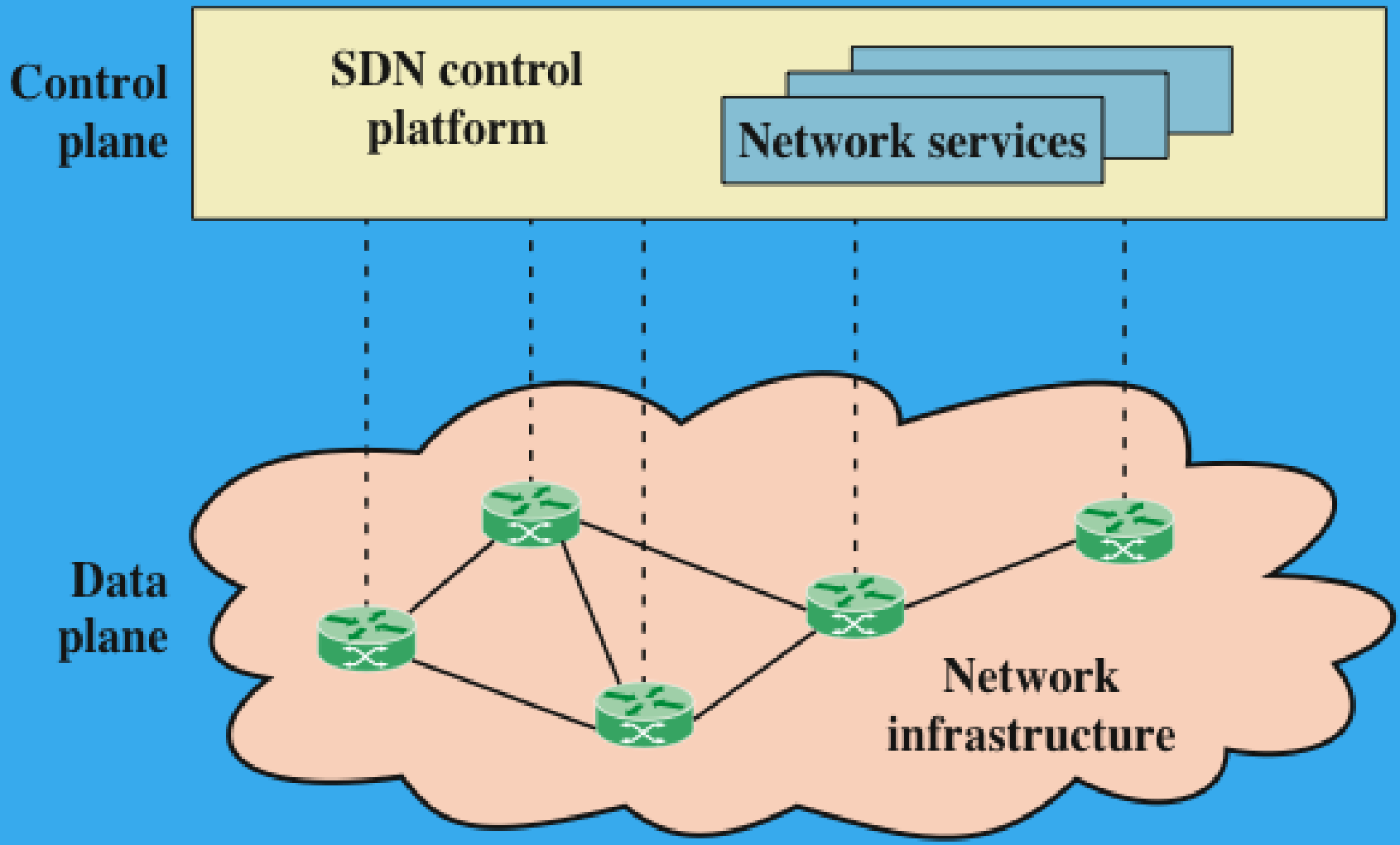

Figure 2.15 Software-Defined Networking

Software-Defined Networking (SDN)

- A driving factor for SDN is the increasingly widespread use of server virtualization
- In essence, server virtualization masks server resources from server users, making it possible to partition a single machine into multiple, independent servers, conserving hardware resources
- It also makes it possible to quickly migrate a server from one machine to another for load balancing or for dynamic switchover in the case of machine failure
- Server virtualization has become a central element in dealing with big data applications and in implementing cloud computing infrastructures

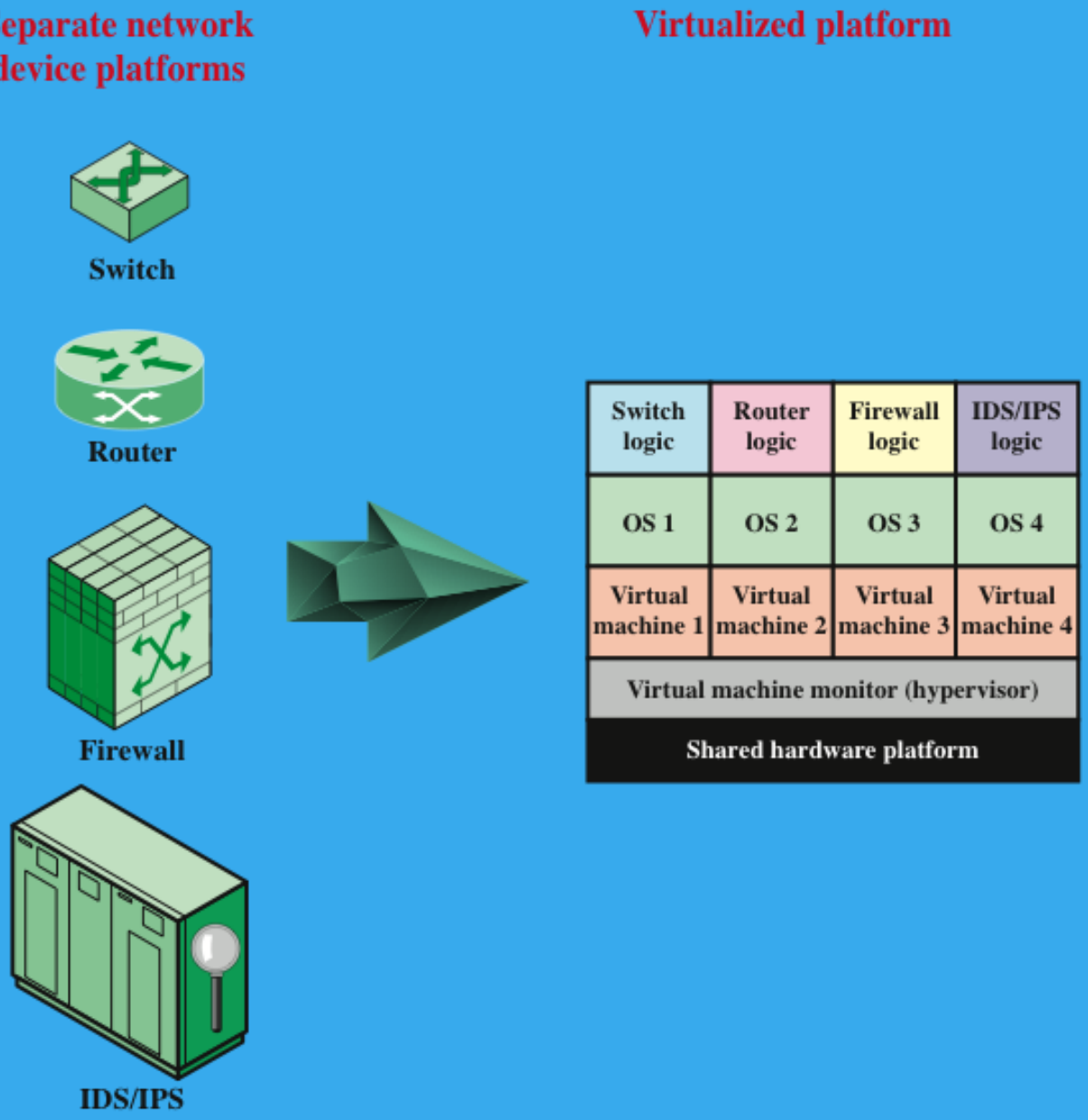

Figure 2.16 Network Functions Virtualization

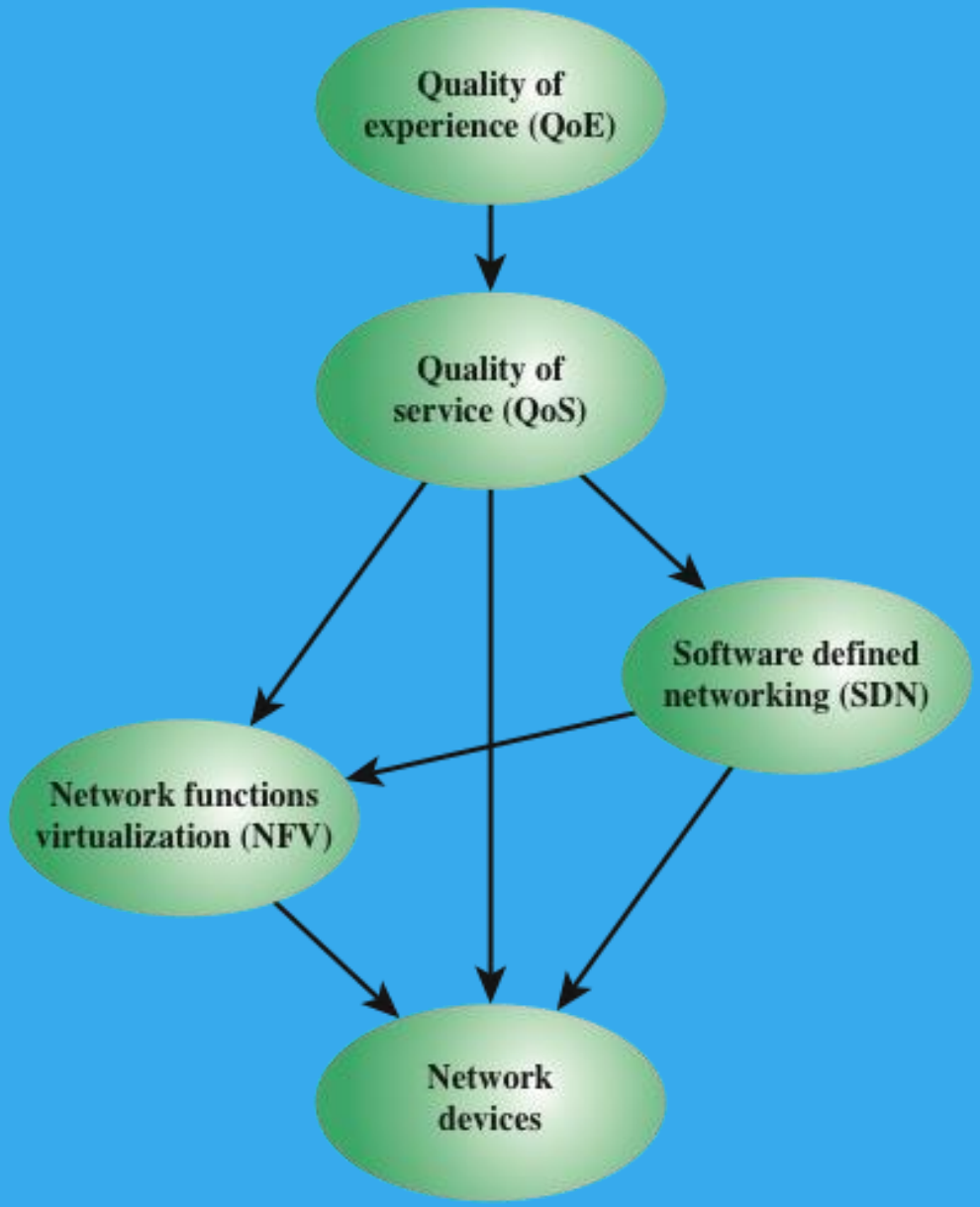

Figure 2.17 Modern Networking Schema

End of Chapter 2

Foundations of Modern Networking

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Chapter 3

SDN: Background and Motivation

Evolving Network Requirements

- A number of trends are driving network providers and users to reevaluate traditional approaches to network architecture
  - Demand is increasing
    - Cloud computing
    - Big data
    - Mobile traffic
    - The Internet of Things (IoT)
  - Supply is increasing
  - Traffic

Traditional Network Architectures are Inadequate

- As QoS and QoE requirements imposed on the network are expanded as a result of the variety of applications, the traffic load must be handled in an increasingly sophisticated and agile fashion
- The traditional internetworking approach is based on the TCP/IP protocol architecture; characteristics of this approach are:
  - Two-level end system addressing
  - Routing based on destination
  - Distributed, autonomous control

Limitations

- The Open Networking Foundation (ONF) cites four general limitations of traditional network architectures:
  - Static, complex architecture
  - Inconsistent policies
  - Inability to scale
  - Vendor dependence

The SDN Approach

- Requirements:

Adaptability	•Networks must adjust and respond dynamically, based on application needs, business policy, and network conditions
Automation	•Policy changes must be automatically propagated so that manual work and errors can be reduced
Maintainability	•Introduction of new features and capabilities must be seamless with minimal disruption of operations
Model management	•Network management software must allow management of the network at a model level, rather than implementing conceptual changes by reconfiguring individual network elements
Mobility	•Control functionality must accommodate mobility, including mobile user devices and virtual servers
Integrated security	•Network applications must integrate seamless security as a core service instead of as an add-on solution
On-demand scaling	•Implementations must have the ability to scale up or scale down the network and its services to support on-demand requests

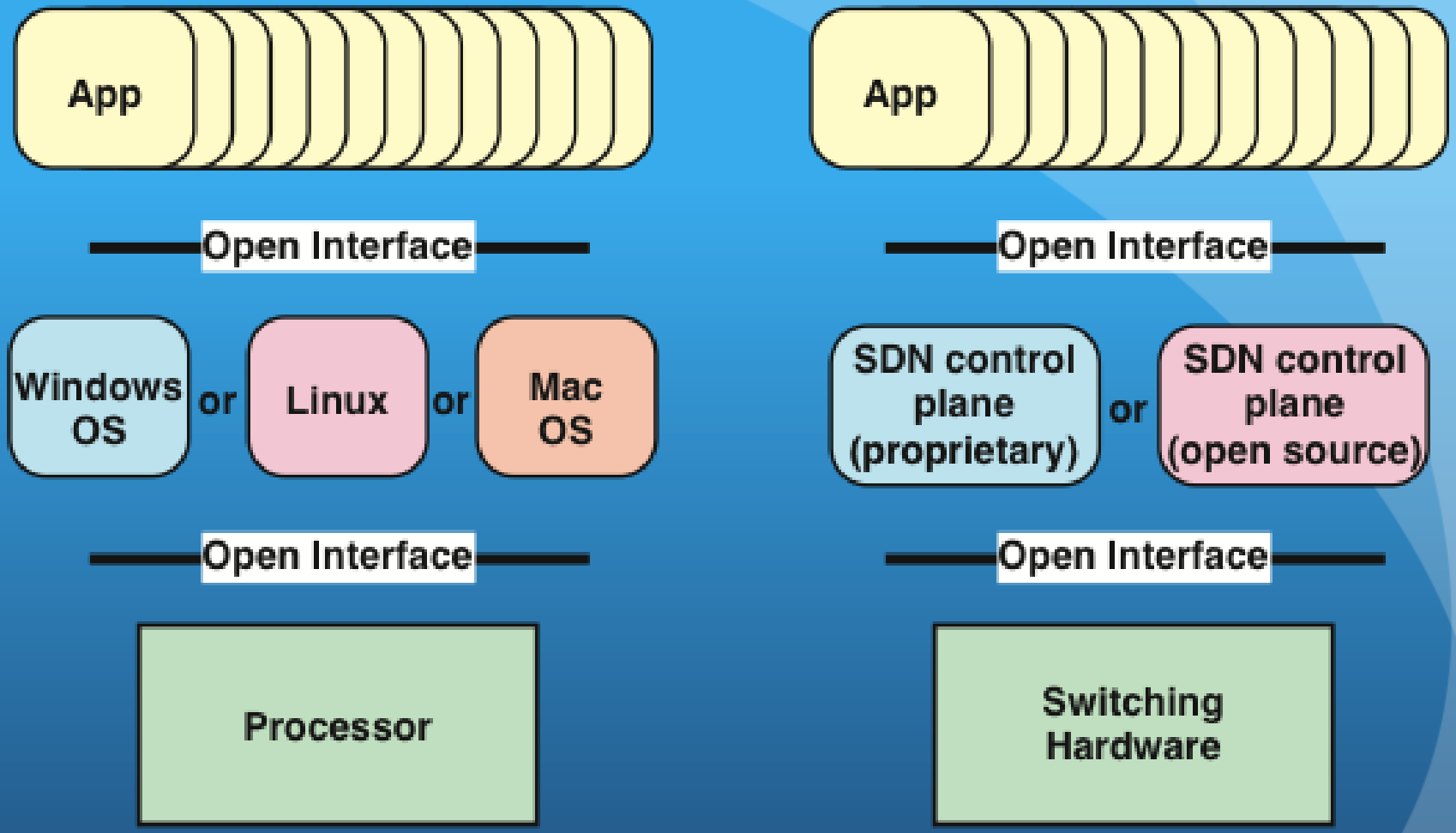

Figure 3.1 The Modern Approach to Computing and Networking

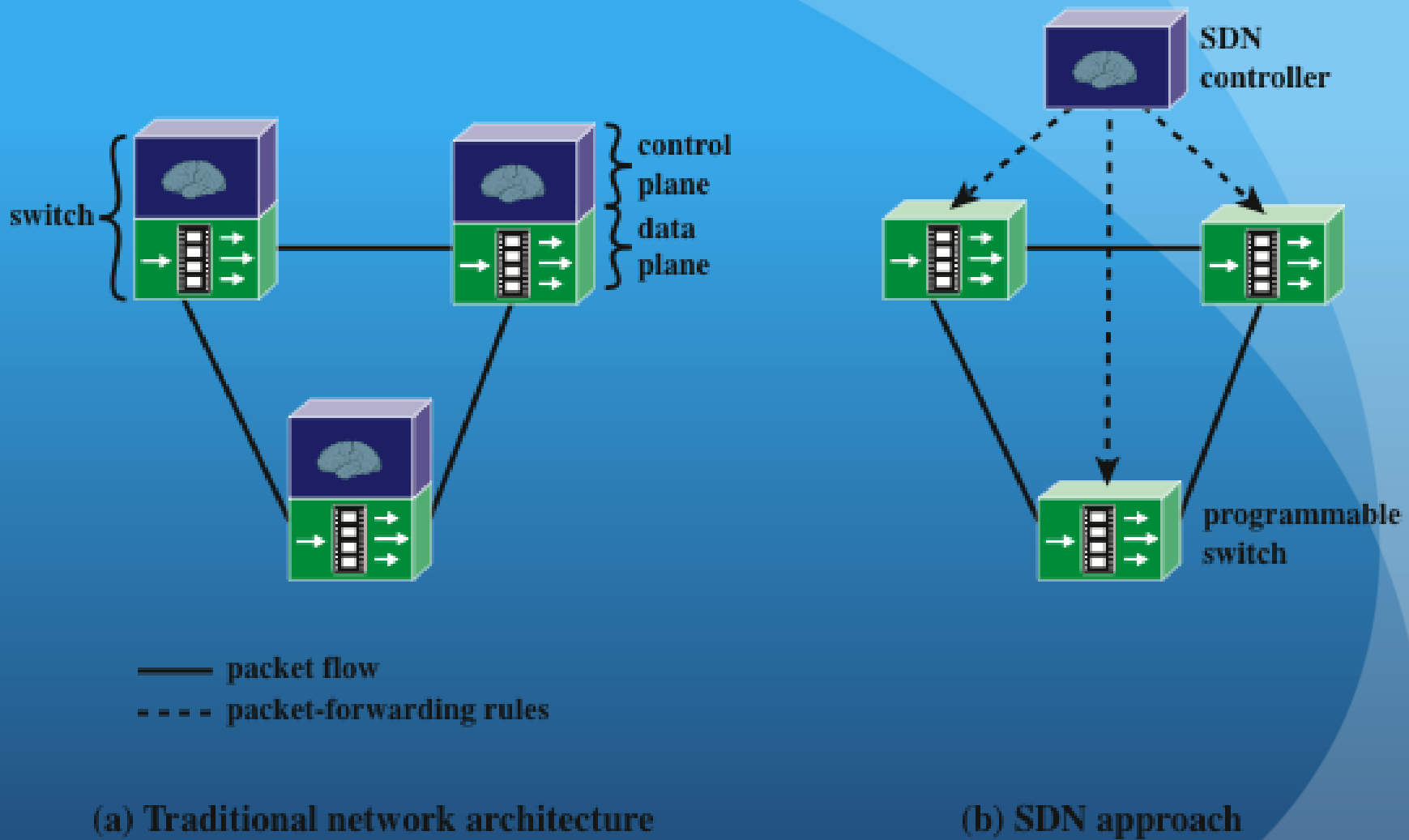

Figure 3.2 Control and Data Planes

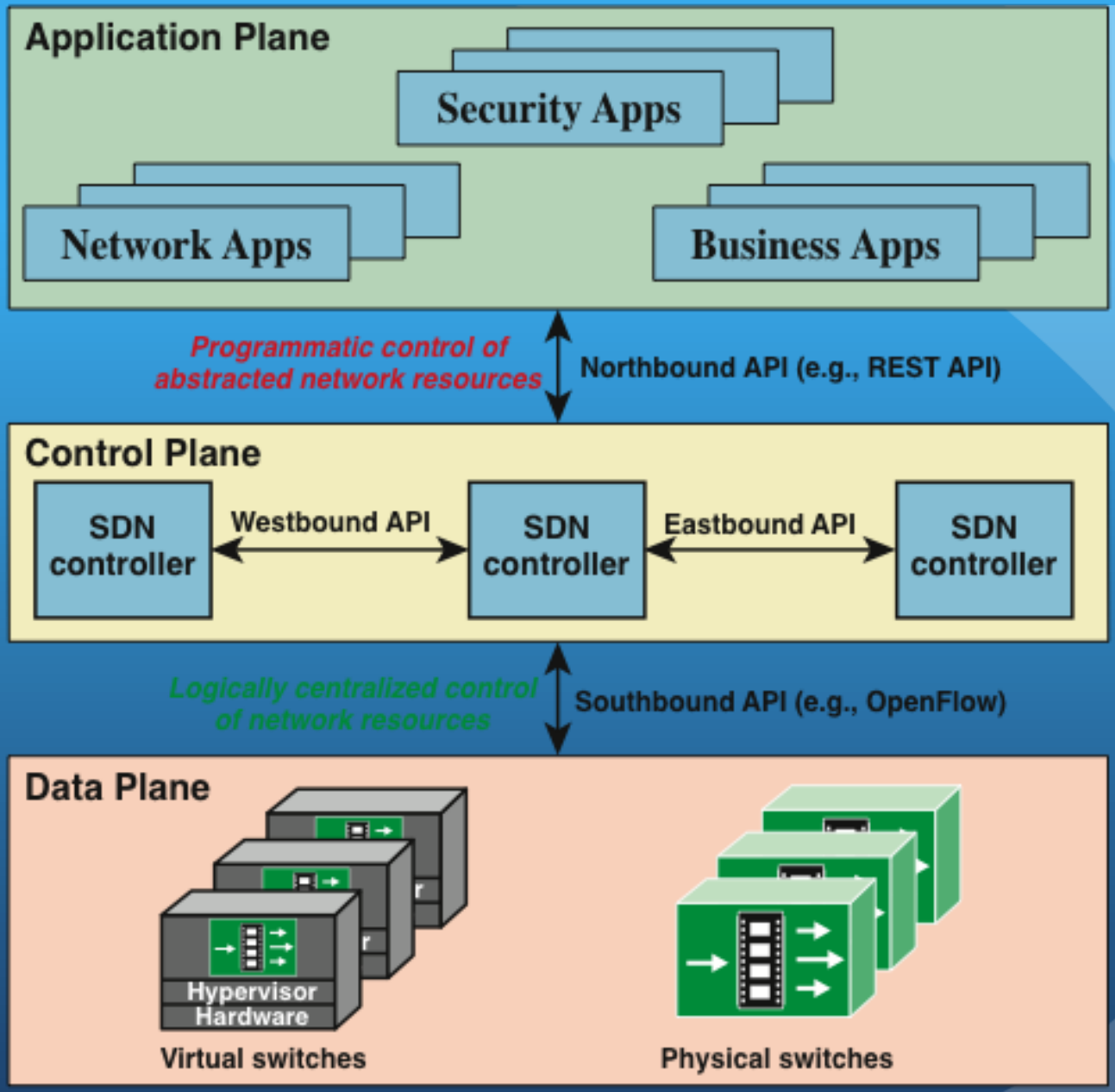

Figure 3.3 SDN Architecture

Characteristics of Software-Defined Networking

- The control plane is separated from the data plane; data plane devices become simple packet-forwarding devices
- The control plane is implemented in a centralized controller or set of coordinated centralized controllers
  - The SDN controller has a centralized view of the network or networks under its control
  - The controller is portable software that can run on commodity servers and is capable of programming the forwarding devices based on a centralized view of the network
- Open interfaces are defined between the devices in the control plane (controllers) and those in the data plane
- The network is programmable by applications running on top of the SDN controllers; the SDN controllers present an abstract view of network resources to the applications

Organization	Mission	SDN-related effort
Open Networking Foundation (ONF)	An industry consortium dedicated to the promotion and adoption of SDN through open standards development.	OpenFlow
Internet Engineering Task Force (IETF)	The Internet's technical standards body. Produces RFCs and Internet Standards.	Interface to Routing Systems (I2RS) Service Function Chaining
European Telecommunications Standards Institute (ETSI)	An EU-sponsored standards organization that produces globally-applicable standards for information and communications technologies.	NFV Architecture
OpenDaylight	A collaborative project under the auspices of the Linux Foundation	OpenDaylight
International Telecommunication Union—Telecommunication Standardization Sector (ITU-T)	United Nations agency that produces Recommendations with a view to standardizing telecommunications on a worldwide basis.	SDN functional requirements and architecture
Internet Research Task Force (IRTF) Software Defined Networking Research Group (SDNRG)	Research group within IRTF. Produces SDN-related RFCs.	SDN architecture
Broadband Forum (BBF)	Industry consortium developing broadband packet networking specifications.	Requirements and framework for SDN in telecommunications broadband networks
Metro Ethernet Forum (MEF)	Industry consortium that promotes the use of Ethernet for metropolitan and wide area applications.	Defining APIs for service orchestration over SDN and NFV
IEEE 802	An IEEE committee responsible for developing standards for local area networks (LANs)	Standardize SDN capabilities on access networks.
Optical Internetworking Forum (OIF)	Industry consortium promoting development and deployment of interoperable networking solutions and services) for optical networking products	Requirements on Transport Networks in SDN Architectures
Open Data Center Alliance (ODCA)	Consortium of leading IT organizations developing interoperable solutions and services for cloud computing.	SDN Usage Model
Alliance for Telecommunications Industry Solutions (ATIS)	A standards organization that develops standards for the unified communications (UC) industry.	Operational Opportunities and Challenges of SDN/NFV Programmable Infrastructure
Open Platform for NFV (OPNFV)	An open source project focused on accelerating the evolution of NFV.	NFV intrastructure

Table 3.1

SDN and NFV Standards Activities

Standards-Developing Organizations

- **Internet Society (ISOC)**
  - The coordinating committee for Internet design, engineering, and management
  - Areas covered include the operation of the Internet itself and the standardization of protocols used by end systems on the Internet for interoperability
  - Various organizations under the ISOC are responsible for the actual work of standards development and publication

Internet Engineering Task Force (IETF)

- Has working groups developing SDN-related specifications in the following areas:

Interface to routing systems (I2RS)

Develop capabilities to interact with routers and routing protocols to apply routing policies

Service function chaining

Develop an architecture and capabilities for controllers to direct subsets of traffic across the network in such a way that each virtual service platform sees only the traffic it must work with

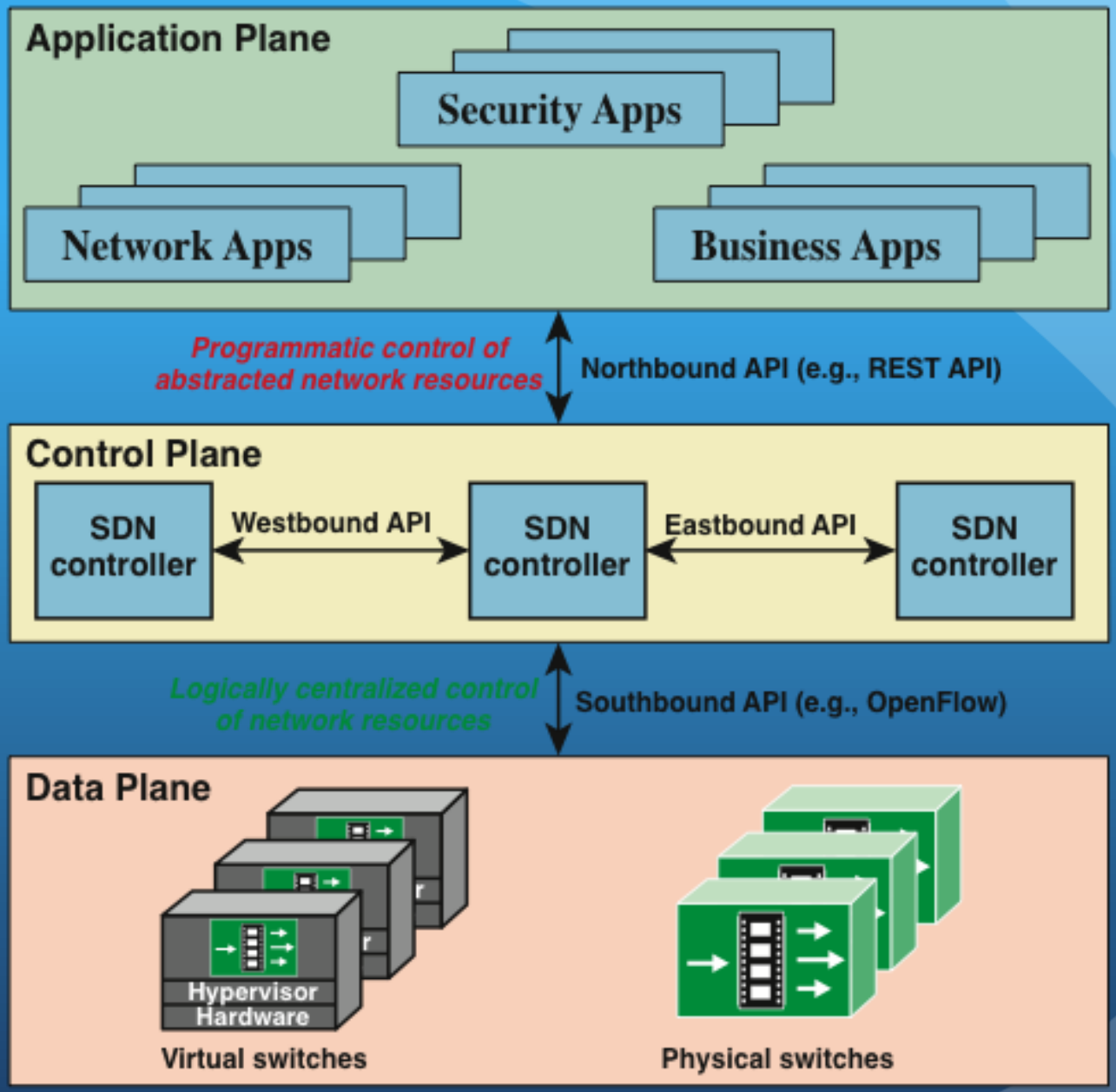

Figure 3.3 SDN Architecture

International Telecommunications Union – Telecommunication Standardization (ITU-T)

- A UN agency that issues standards, called recommendations, in the telecommunications area
  - So far, their only published contribution to SDN is Recommendation Y.3300 (*Framework of Software-Defined Networking*, June 2014)
- Has established a Joint Coordination Activity on Software-Defined Networking (JCA-SDN) and began work on developing SDN-related activities
- Four ITU-T study groups are involved in SDN-related activities:
  - SG 13 (Future networks, including cloud computing, mobile, and next-generation networks)
  - SG 11 (Signaling requirements, protocols, and test specifications)
  - SG 15 (Transport, access, and home)
  - SG 16 (Multimedia)

European Telecommunications Standards Institute (ETSI)

- Recognized by the European Union as a European Standards Organization
- Not-for-profit Standards Development Organization (SDO) has member organizations worldwide and its standards have international impact
- Has taken the lead role in defining standards for NFV
- ETSI's Network Functions Virtualization (NFV) Industry Specification Group (ISG) began work in January 2013 and produced a first set of specifications in January 2015
- The 11 specifications include an NFV's architecture, infrastructure, service quality metrics, management and orchestration, resiliency requirements, and security guidance